Environmental Health Perspectives
Vol. 53, pp. 91–98, 1983

Epidemiology Study of the Use of Asbestos-Cement Pipe for the Distribution of Drinking Water in Escambia County, Florida

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Cancer mortality for the population census tracts of Escambia County, FL, which use asbestos-cement (AC) pipe for public potable water distribution, was compared with cancer mortality data collected from census tracts in the same county where other types of piping materials are used. An analysis of covariance was run to test for differences in standard mortality ratios for seven cancer sites among three potential asbestos exposure groups based on AC pipe usage. Twelve variables representing nonexposure-related influences on disease rates were combined in four independent factors and used as covariates in these analyses. No evidence for an association between the use of AC pipe for carrying drinking water and deaths due to gastrointestinal and related cancers was found. The limitations on the sensitivity of the analysis are discussed.

Introduction

Concern over the presence of asbestos fibers in drinking water supplies began in 1973 after millions of mineral fibers per liter were reported in the drinking water in Duluth, MN (*1, 2*). The question of possible increased risk of disease resulting from long-term ingestion of asbestos fibers in drinking waters is important because the association between some occupationally exposed asbestos workers and increased risk of respiratory and digestive disease has been documented (*3, 4*).

In June 1974, electron microscopy confirmed that fibrous material recovered from a kitchen faucet strainer in Pensacola, FL, was asbestos. While the source of mineral fibers in the Duluth water supply was related to industrial discharge of mining wastes, the fibers in the Pensacola water appeared to be connected with the deterioration of asbestos-cement (AC) distribution mains. Because AC pipe is used to carry drinking water throughout the United States, it was decided that a study of people should be conducted, by census tracts, in an area where there was evidence of fibers coming from the pipe.

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Study Area

Escambia County is located on the Gulf Coast in the upper panhandle of Florida. A little over 200,000 people live in the county, which is divided demographically into 40 census tracts. Some of the tracts have been receiving water through AC pipe for 30–40 yr, other tracts have been serviced by nothing but cast iron pipe, and still others receive water primarily from private wells with no AC pipe. Data on water quality from 25 wells showed unfinished waters in the county to be very similar, all with the chemical characteristics that make water corrosive to most types of common plumbing materials as well as to unprotected water mains. Comparison of water quality data from 1951 and 1957 and 1975 data showed that the well source waters had changed little in their chemical characteristics over the years. With the assistance of Escambia County Health Department personnel, an exposure assessment and a compilation of cancer mortality data were conducted in simultaneous but separate projects to determine whether or not the people in the county using AC pipes showed a greater risk of disease.

Exposure Evaluation

Seven water samples were taken over the period of a year from the Montclair water distribution system, where the asbestos material had been found in a kitchen faucet strainer. The drinking water was analyzed by newly developed electron microscopic techniques (*5*). As seen in Table 1, varying amounts of asbestos fibers were found in the consumers' drinking water. The absence of fibers in the well samples indicated that the asbestos fibers found in the distribution system probably originated in the AC pipe. The first sampling point, Residence 1, was in a house on the older part of the water system, and Residence 2, in a house on the newest part. During the sampling period, fiber concentrations in the water may have been influenced by changing treatment practices at the well source; utility personnel monitored the system more closely and increased the dosage of lime in an attempt to make the water less corrosive to AC pipe. Later inspections of excavated sections of pipe confirmed that the pipe was releasing fibers, as it showed rather severe deterioration of the interior pipe surface. Some of the chemical qualities of the water that caused it to be so aggressive were low pH (5.2), low calcium hardness (1.4 mg/L as $CaCO_3$), and low alkalinity (1 mg/L as $CaCO_3$). According to current American Water Works Association standards, these qualities indicate water that, if left untreated, would be highly corrosive and might eventually destroy the structural integrity of AC pipe. In earlier days, however, AC pipe was selected because it was thought to be free from the corrosion problems that were experienced with metal pipe, and its use in corrosive water situations had eliminated red water (iron corrosion) complaints.

Discussions with local utility personnel indicated that the pipe deterioration of the Montclair system was not truly representative of all the AC pipe in Escambia County. The Montclair system, established in 1957 and expanded through 1968, was privately owned originally and apparently its water was not treated consistently. There were numerous consumer complaints about waterborne fibers, clogged customer meters, and problems at a coin-operated laundry, all of which were attributed to fiber release from the AC pipe. An inspection of the Montclair treatment facilities on June 4, 1964, by the county health department disclosed no stabilization treatment equipment in operation and a "heavy solid load in the water in the form of asbestos fibers." When the system was acquired by the municipality in 1968, lime treatment to reduce corrosiveness was started on a continuous basis, and the system was flushed and interconnected with the overall city system. Most customer complaints subsided after the municipal acquisition but, occasionally, visible clumps of fibers were recovered, as in the June 1974 case.

Utility records for the greater part of Escambia County did not show AC pipe unearthed from areas other than the Montclair system to be as severely deteriorated as the pipe in that system. The average raw water quality in 1976 for the 25 wells in the Pensacola City system showed a pH

Table 1. Asbestos fiber counts for the Montclair System sample points.

Date of sample	Fiber counts, 10^6 fibers/L[a,b]					
	Well		Residence 1		Residence 2	
	Amphibole	Chrysotile	Amphibole	Chrysotile	Amphibole	Chrysotile
01/17/75	BDL (0.01)	0.02	0.01	1.7	0.2	1.2
02/21/75	BDL (0.01)	NSS (0.06)	NSS (0.03)	32.7	BDL (0.02)	0.4
03/26/75	BDL (0.01)	NSS (0.01)	NSS (0.1)	1.7	BDL (0.02)	0.3
05/09/75	BDL (0.01)	NSS (0.01)	BDL (0.01)	1.2	BDL (0.02)	0.7
07/07/75	BDL (0.01)	NSS (0.06)	NSS (0.06)	0.7	BDL (0.01)	0.1
09/05/75	BDL (0.01)	NSS (0.01)	NSS (0.06)	0.2	BDL (0.01)	BDL (0.01)
12/04/75	BDL (0.01)	BDL (0.01)	BDL (0.01)	0.4	BDL (0.01)	BDL (0.01)
12/08/77	BDL (0.05)	NSS (0.05)	BDL (0.05)	NSS (0.01)	NSS (0.1)	NSS (0.2)
01/29/79	c	c	01	0.7	c	c

[a]BDL = Below detectable limit (shown in parentheses).

[b]NSS = Not statistically significant. Value shown in parentheses is based on too few fibers found in analysis to be considered accurate.

[c]Not sampled.

of 5.2, a calcium hardness of 18 mg/L as $CaCO_3$, and an alkalinity of 2.5 mg/L as $CaCO_3$. While this suggests a highly corrosive water, each well was equipped with a lime treatment system designed, not necessarily to stabilize the water, but to make the distributed water less corrosive. Monitoring the multitude of mechanical feeders was not, however, an easy task, and the corrosiveness of the water varied over the years. A sample taken from the distribution system of Pensacola in 1951 for the Florida State Board of Health showed that the treated water had a tendency to be corrosive, with a pH of 7.3, a calcium hardness of 25 mg/L as $CaCO_3$ and an alkalinity of 30 mg/L as $CaCO_3$. The Langlier index of this sample was determined to be −1.6. The water itself was clear with no sediment. Prior to 1977, the occurrence of corrosive water was also evidenced by red water complaints from areas that used cast iron pipe. In 1977, pH recorders with hi-lo alarms were installed at the well plants and were connected to a central control room. Red water complaints decreased drastically after this careful monitoring began.

The Escambia County Health Department was asked to collect water samples from residences that they felt to be representative of the water systems in the county. The analysis results of all the samples collected are shown in Table 2. Some water samples taken from census tracts using AC pipe showed measurable asbestos concentrations, while others did not. The increase in the lime dosages in many of the individual well plants after 1975 may have had an influence on fiber counts. The changing water flow patterns throughout the connected systems may also have caused waters from a system with one type of pipe to flow into another. Care was taken to sample only from consumers' homes rather than from fire hydrants, and samples were not taken when work on the pipe was underway near the sampling site. Chemical analyses of water samples collected in December 1977 (Table 3) showed that many of the waters at the consumers' taps still had the capability to be moderately corrosive. In a system where a corrosive water is attacking AC piping material, the water would change chemically and become less corrosive as it moved through the system. Although there was some indication of pH and calcium change in the water as it flowed through the Montclair system, water in other systems in the county could not be studied closely for this effect because of changing treatment practices at each well. There is some evidence from other studies that iron entering the water from the corrosion of cast iron lines near the source of a

Table 2. Asbestos fiber counts from homes in various census tracts.

Census tract	Sample number	Date of sample	Concn, 10^6 fibers/L[a,b] Amphibole		Chrysotile		Principal area pipe characteristics
3	39719	12/07/77	BDL	(0.05)	BDL	(0.05)	Fe
4	39720	12/07/77	BDL	(0.05)	BDL	(0.05)	Fe
6	39716	12/07/77	BDL	(0.03)	NSS	(0.16)	Fe
9	39717	12/07/77	BDL	(0.05)	NSS	(0.24)	Fe
10	39718	12/07/77	BDL	(0.05)	BDL	(0.05)	50% AC/50% Fe
13	39725	12/08/77	NSS	(0.24)	NSS	(0.24)	AC
22	39730	12/08/77	NSS	(0.16)	NSS	(0.16)	AC
23	39729	12/08/77	BDL	(0.02)	NSS	(0.12)	AC
27	35454	08/10/76	NSS	(0.1)		0.4	AC
29	39721	12/07/77	BDL	(0.05)	NSS	(0.24)	AC
30	39722	12/07/77	BDL	(0.05)	NSS	(0.24)	AC
31	39723	12/08/77	BDL	(0.05)	NSS	(0.16)	AC
32	39724	12/08/77	NSS	(0.24)	NSS	(0.24)	AC
33	40615	04/14/76	NSS	(0.1)		3.2	AC
33	35457	08/10/76		0.1		10.7	AC
33	39728	12/08/77	BDL	(0.02)	NSS	(0.12)	AC
33	39754	01/29/79	NSS	(0.05)		0.7	AC
34	40617	04/14/76	NSS	(0.1)		0.7	AC
35	40616	04/14/76	BDL	(0.01)	NSS	(0.05)	AC
35	35455	08/10/76	BDL	(0.02)		0.1	AC
35	35455	08/10/76		0.5		4.7	AC
35	39726	12/08/77	BDL	(0.03)		0.16	AC
37	39727	12/08/77	BDL	(0.03)	NSS	(0.16)	Fe

[a]BDL = Below detectable limit (shown in parentheses).
[b]NSS = Not statistically significant. Value shown in parentheses is based on too few fibers found in analysis to be considered accurate.

Table 3. Some water quality values from home faucet samples collected 12/7–8/77.

Census tract	Sample number	Field pH	Lab pH	Alkalinity, mg/L	Calcium, mg/L	Total iron, mg/L	AI[a]	Principal area pipe characteristics
3	39719	6.6	7.2	31	37.5	0.45	10.3	Fe
3	39725	7.8	7.7	27	29.7		10.6	AC
4	39720	6.8	7.5	32	25.5	0.46	10.4	Fe
6	39716	7.0	7.6	44	59	0.17	10.7	Fe
9	39717	6.2	6.6	9	13	0.07	8.7	Fe
10	39718	5.7	6.6	9	8.3	0.07	8.5	50% AC/50% Fe
22	39730	6.8	7.5	30	30.5		10.5	AC
23	39729	6.8	7.6	36	35.0		10.7	AC
29	39721	8.0	8.1	34	41.3	0.07	11.2	AC
30	39722	7.6	7.7	36	43.7	0.07	10.8	AC
31	39723	8.4	8.4	31	34.5		10.4	AC
32	39724	7.8	7.9	34	38.3		11.0	AC
33	39728	6.4	7.1	15	15		9.4	AC
35	39726	7.4	7.5	26	28.2		10.4	AC
37	39727	9.6	9.0	50	53.7		12.4	AC

[a]AI = Aggressive Index = pH + log (AH), where A = total alkalinity in mg/L as $CaCO_3$ and H = calcium hardness in mg/L as $CaCO_2$.

system may have a protective effect on AC pipe further on in the distribution system. There were no utility reports of iron coatings on AC pipe unearthed. Nevertheless, the reports of red water problems suggest this may have occurred in some areas.

Data from analysis of the water samples showed asbestos fibers in the drinking waters of some areas. However, the changing water treatment practices at the well plants over the years prevented these data and the data from later samplings to be used specifically to estimate past exposures. Instead, the Escambia County census tracts were divided into three potential exposure groups based on years of use and amount of AC pipe, as follows.

Potential High Exposure. At least 90% of the population was served by AC pipe for 25 yr or more in 1976 (9 tracts). Tract numbers: 13, 17, 19, 20, 27, 29, 30, 31, 33; population: 46, 123.

Low Exposure. Less than 90% of the tract population was served by AC pipe or, if over 90% of the population was served by AC pipe, the pipe was less than 25 yr old in 1976 (13 tracts). Tract numbers: 3, 10, 11, 12, 14, 18, 21, 26, 28, 32, 34, 35, 36; population: 86,897.

No Exposure. No AC pipe was used in the census tract. Either cast iron pipe was used, or the tract population was not on public water supply (14 tracts). Tract numbers: 1, 2, 4, 5, 6, 7, 8, 9, 15, 16, 37, 38, 39, 40; population: 51,378.

Figures 1 and 2 show maps of the geographic distribution of the census tracts assigned to different potential exposure classification groups. It should be noted that census tracts 1, 2, 4, 5, 6 and 7 are in the city of Pensacola and census tracts 38, 39 and 40 are in a rural area of the county. Census tract 37 is centered around a papermill.

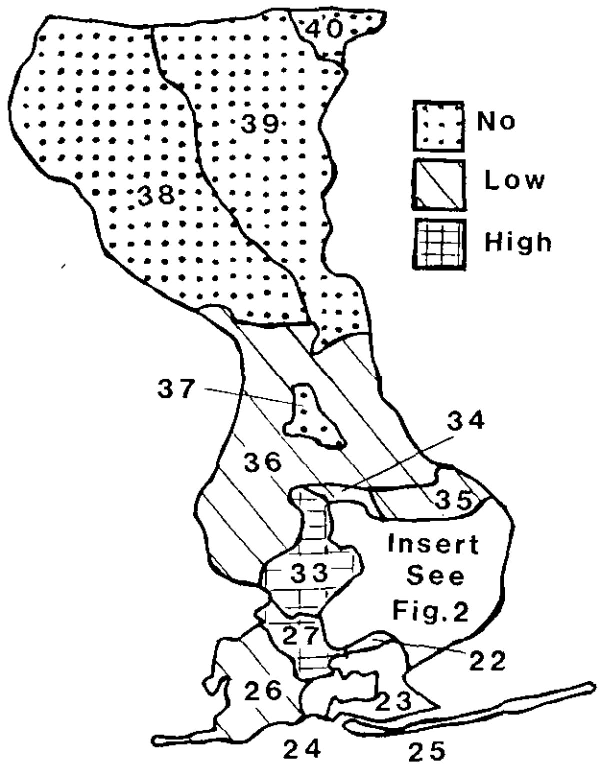

FIGURE 1. Census tracts in Escambia County, FL, with an indication of exposure to asbestos-cement pipe used for the delivery of drinking water.

Utility personnel indicated that all AC pipe in the county was thought to be type II pipe. Pipe of this classification is autoclaved and is more corro-

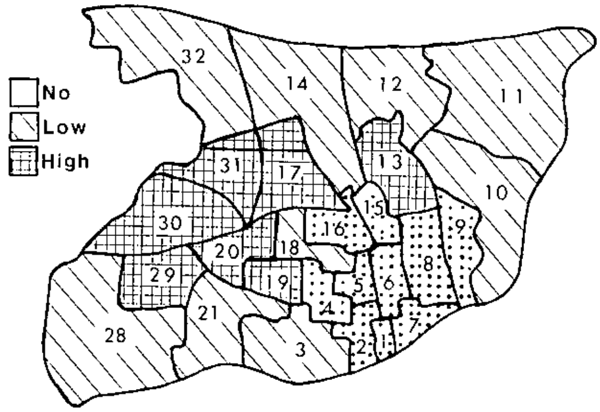

FIGURE 2. Detail of Figure 1. Central county census tracts with an indication of the exposure to asbestos-cement pipe.

sion resistant than type I pipe. Only populations exposed for 25 yr or more were included in the potentially high exposure category because studies of occupationally exposed asbestos workers show a latency period of at least 20 yr between initial exposure and onset of disease (*6*). Because most of the systems are interconnected, water may have, on occasion, flowed from a system with one type of piping into a system with a different type of piping. Although this factor could not be considered when assigning census tracts to potential exposure groups, it probably did not significantly alter exposure patterns over any great length of time. Health Department personnel determined that the flow would usually be from systems with iron pipe to those with AC pipe when mixing did occur. The Montclair system is found in both census tracts 31 and 32. The newer AC pipe section is in tract 32. Four census tracts (total population: 20,936) were not included. Tract 25 is a beach area where housing is mostly less than 5 yr old. Tract 24 is a naval base with their own water supply. Tracts 22 and 23 were not included because Escambia County Health Department officials felt that the tracts would have very high migration patterns because the residents are mostly Navy personnel.

Cancer Data

Because neither a tumor registry existed for Escambia County nor were morbidity statistics available, an Escambia County Health Department official examined all death certificates from 1963 to 1976 by hand. Cancer deaths for the sites listed in Table 4 were recorded by year for each census tract along with data from the death certificate including age, sex and race (white or nonwhite).

A sex-site specific standard mortality ratio (SMR), i.e., the ratio of the expected to observed deaths, was calculated for each tract by using the 1970 U.S. population age-sex-race-site specific rates as standard rates. Eight age categories (0–24, 25–34, 35–44, 45–54, 55–59, 60–64, 65–74, 75 and older) and two race categories (white and nonwhite) were used.

Other Variables

Data on other variables that might influence cancer disease rates were obtained for each census tract. Table 5 lists 12 variables that provided some measure for the parameters of socioeconomic status, occupation, residence stability, and population density. The socioeconomic variables included 1970 census data (*7*) from mean income (INCOME); percent of households below the poverty level (PHOUSE); percentage of high school graduates (PHSG); median year of school com-

Table 4. Summary of raw data for actual numbers of deaths (1963–1976) by exposure group for all age groups, races, both sexes.

		Exposure group		
	Code[a]	No	Low	High
1970 Population	—	51378	86897	46123
Bladder	188	32	26	23
Kidneys	189	5	10	8
Gastrointestinal[b]	150–159	155	128	131
Pancreas	157	66	61	58
Liver	155	16	17	15
Lungs	162	256	253	277
Other, excluding skin	170–171, 174, 190–199	448	371	350

[a]International Classification of Disease for Oncology, WHO, 1976.
[b]Includes esophagus, stomach, intestines, colon, rectum, liver, gallbladder, pancreas, pertitoneum.

Table 5. Socioeconomic indicators.

Code	Description
1. INCOME	Mean income of census tract
2. PHOUSE	% households below poverty
3. PLABOR	% in total labor force
4. PCONST	% working in construction
5. PMANUF	% working in manufacturing
6. PHSG	% high school graduate
7. SHOUSE	% resident same house in 1970 as in 1965
8. OHOUSE	% resident in other house same SMSA
9. PTRANP	% working in transportation
10. SEX	Male/female ratio in census tract
11. PMYR	Median school year complete
12. POPDEN	Population density

pleted (PMYR); and percentage of the work force working in construction (PCONST), manufacturing (PMANUF), or transportation (PTRANP). According to Escambia County Health Department information, the county had no asbestos product manufacturing companies. Data on the number of residents in the same house in 1965 as in 1970 (SHOUSE) and in the same area (Standard Metropolitan Statistical Area) (OHOUSE) were chosen to represent population stability. Population density (POPD), which has been cited as a potentially important factor in other studies of ingested asbestos, was calculated from data supplied by the West Florida Regional Planning Council.

Data Analysis

For each of the cancer types listed in Table 4, an analysis of covariance (*8,9*) was run to test for differences in SMRs among potential exposure groups (high, low, no). In order to adequately satisfy the assumptions needed for an analyses of covariance (e.g., normality), the square root of the SMR was used as the dependent variable. The 12 highly interrelated nonexposure variables listed and defined in Table 5 were reduced to four uncorrelated composite variables by principal components analysis. These new variables (factor scores), representing a composite of nonexposure-related influences on disease rates, were used as covariates in these analyses (*8,10*). Factor 1 was basically a socioeconomic class variable. The main contributions to this factor were from the variables INCOME, PHOUSE, PHSG, and PMYR. Factor 2 was made up of mainly SEX and PLABOR (which was the only variable other than sex to differ between the sexes) and is the sex class variable. Factor 3 was made up of mainly SHOUSE, OHOUSE, POPDEN, PCONST, and reflected some measure of mobility. Factor 4 was made up of mainly PMANUF and PTRANP and reflected these job classes.

Results

As seen in Table 6, there were no cancer sites for which the SMRs differed significantly ($p < 0.05$ level) between census tract groups having potentially different asbestos fiber concentrations in their waters. The R^2 values for all sites were less than 0.25 except for the site category of "other."

Discussion

The results of the analyses in this study do not show any statistical association between the deaths due to certain cancer types and the use of AC pipe in Escambia County, FL. This conclusion is consistent with the results of a previous study of cancer incidence in Connecticut towns using AC pipe (*11*). No other published epidemiologic studies have specifically considered AC pipe.

In this type of epidemiology study, it is not possible to assess the possible influences of such individual factors as smoking, occupation, and alcohol consumption on disease. These factors have been discussed in previously published studies of the same type that considered exposure to asbestos in drinking water (*12,13*). The R^2 values, which indicated that less than 25% of the variation between exposure groups was accounted for by the general census tract level factors considered, were similar to the R^2 values of the other studies (*11–13*). Only the composite factor 4 showed a regression coefficient significantly different from zero for any sites ($p < 0.05$). This factor is most heavily influenced by the job classes of manufacturing and transportation, but the in-

Table 6. Exposure group mean SMR values for cancer sites.

Potential exposure	SMR							
	GI	Pancreas	Kidneys	Bladder	Urinary[a]	Liver	Lungs	Other[b]
Adjusted mean SMR (square root transformation)								
High	0.721	0.848	0.221	0.632	0.551	0.925	1.092	1.671
Low	0.651	1.013	0.296	0.839	0.722	1.04	1.087	1.676
No	0.596	0.822	0.339	0.638	0.602	0.727	0.903	1.555
Probability value	0.184	0.462	0.758	0.511	0.477	0.7389	0.245	0.546
R^2	0.21	0.17	0.15	0.11	0.14	0.01	0.16	0.46
Mean SMR values								
High	0.563	0.989	0.330	0.850	0.590	2.132	1.256	2.753
Low	0.456	1.083	0.417	1.026	0.687	1.987	1.178	2.698
No	0.407	1.074	0.173	0.744	0.554	1.329	1.035	2.947

[a]Combined kidneys and bladder.
[b]Other unspecified sites.

terpretation of its statistical significance is difficult because the other nonexposure variables also have some effect on the markup of this factor.

The size of the population involved in this study is an important factor. For those cancers with low frequencies of occurrence, the results must be interpreted carefully, since one or two deaths could change the results enough to alter the conclusions. In this study, mortality due to kidney cancer did not occur in great numbers. Of the census tracts, 75% had no deaths from kidney cancer over the 14-yr period studied. Four census tracts had recorded two deaths from kidney cancer; two were in the high exposure group and one each in the low and no exposure groups.

It is apparent from the maps in Figures 1 and 2 that the census tracts assigned to the various exposure groups are also grouped geographically. This is an obvious consequence of studying piping materials in a connected water distribution system. Whether this physical alignment of tracts is a confounding bias could not be readily assessed with existing data. Attempts were made, however, to control for socioeconomic differences that might be related both to the geographic groupings and disease mortality. In previous studies of asbestos in water, the population density and population mobility were found to be important factors (*12, 13*). As seen in Table 7, the "no" exposure group, containing both the central city census tracts of Pensacola and the rural tracts in the northern part of the county, had both the highest and lowest census tract population densities. The range of densities within this exposure group was over three orders of magnitude. The other two exposure groups had a much smaller range of population density values. Analyzing the data without considering population density had some effect on the adjusted SMRs but did not alter the results. The direct effect of population density itself was not measured since independent composite factors were used as covariates. Differences among SMRs in the analyses of the gastrointestinal cancer site were greater when population density was included in the analysis.

Population mobility may be especially important in asbestos-related cancer studies due to the long latency period between initial exposure and onset of disease. As indicated in one study (*12*), population movement into, out of, and within an area could conceivably result in findings that either showed an association where none existed or masked a real difference in cancer associated with the use of AC pipe. As can be seen in Table 7, population stability, as measured by the percentage of population 5 yr old or older living in the same house in 1970 as in 1965, was similar for the three exposure groups. All three were near the 47% level of the "high stability" super tracts analyzed in the California Bay Area asbestos study (*12*). The fact that about 50% of the people had moved in a 5-yr period casts doubts on the usefulness of this type of study for diseases with long latency periods. Acknowledging that some people may move several times in a period of years, the data in Table 7 suggest that possibly less than one-tenth of the people in the "possible high" exposure census tract group in the 1970s were actually using water delivered by AC pipe 25 yr earlier.

The sensitivity of the statistical analyses is an important consideration. The study should have been able to detect a 70% increase in gastrointestinal cancer mortality in the population with high exposure to AC pipe versus the population with no exposure ($\alpha = 0.05$). However, the ability to identify an association, if one existed, with the individual cancer sites of kidneys, bladder or liver was poor. Because of the small numbers of deaths due to cancer of those sites, a 300% increase would not have been identified as statistically significant.

It is useful to compare the Escambia County situation with the calculations on ingested asbestos risk made from occupational data and described in a proposed ambient water quality criteria document (*14*). This exercise suggests that ingestion of 300,000 asbestos fibers/L will result in one cancer death among 100,000 people in 70 years. The validity of calculating this risk value from occupational groups exposed to airborne asbestos is open to question, and the use of it in this

Table 7. Population density and stability.

Exposure group	Population density[a]				Stability, %[b]		
	Median	Mean	Max.	Min.	Mean	Max.	Min.
No	130	3,950	33,000	10	60%	72%	52%
Low	795	1,800	5,500	70	44%	64%	33%
Possible high	1,033	3,200	4,000	300	48%	59%	36%

[a]Density: 1970 census tract population/square miles of census tract.
[b]Population in the same house, 1965/population 5 yr or older in 1970.

calculation should in no way imply its acceptance as a standard-setting value. It is, however, a useful value for evaluating epidemiologic studies of ingested asbestos. The criterion is equivalent to predicting 0.5 cancer cases/million people per year per million fibers per liter. If it is assumed that the exposure level was between 1 and 10 million fibers/L (Table 2) for the exposed population of about 50,000 people, there will be estimated an additional 0.03 to 0.3 cancer cases per year. This would be an additional four deaths maximum to be added to the 14-yr data in Table 4. This increase would be on the order of 2% for gastrointestinal cancer deaths. If the additional cancers estimated by the criterion had occurred, they would not have been detected in the present study. The above calculation requires a number of assumptions, including that of a lifetime (70-yr) exposure for the population at risk. A paper in these proceedings (*15*) has pointed out that the actual average exposure of a population at a given point in time is 31 years. Consideration of this fact serves to decrease the estimated number of cancer deaths that would be predicted and therefore decreases further the chance that an effect could have been detected in this study if in fact an effect was present.

Conclusion

To the level of sensitivity imposed by the limitations described in the discussion, this study found no evidence for an association between the use of AC pipe for carrying drinking water and deaths due to gastrointestinal and related cancers in Escambia County, FL.

The authors thank Mr. Gib Newsome from the Escambia County Health Department; Mr. Buddy Page from the West Florida Regional Planning Council; Mr. G. Michael, Ms. C. Sonich, Ms. M. Snyder, and Mr. P. Clark from the USEPA in Cincinnati; and Mr. Shiferaw Gebremariam formerly with the University of Cincinnati, Department of Biostatistics, for their help on this study.

The complete census tract population breakdown by race, sex, and age necessary for analysis was contained in the Complete Second Count Data of the 1970 Census of Population and Housing for Escambia County, FL, obtained by contract from the National Planning Data Corporation, Ithaca, NY.

The research described in this paper has been peer and administratively reviewed by the U.S. Environmental Protection Agency and approved for presentation and publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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